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CLAIMS <EXCERPT>

[Claim 8] The solid-state imaging device according to claim 1, wherein said pixel separation film is a color filter.

SPECIFICATION <EXCERPT>

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[0028] FIG. 1 is an outline sectional view of the important section of the solid-state imaging device according to the first embodiment of the present invention. In the solid-state imaging device of the first embodiment, a plurality of photoelectric conversion units 2 are embedded with a constant interval in an upper part of the semiconductor substrate 1. Between the adjoining photoelectric conversion units 2, the charge transfer unit (transfer register: not shown) is provided, and the charge read unit (transfer gate: not shown) and the interlayer film 3 are formed to cover all the photoelectric conversion units 2 and the charge transfer units. On the interlayer film 3, each of charge transfer electrodes 4 is formed between the photoelectric conversion units 2 which adjoin with a constant interval, and the surface of each charge transfer electrode 4 is covered with the light-shielding film 5 which specifies the photosensitive field of incident light. On the interlayer film 3, the insulator layer 6 is laminated so that the charge transfer electrode 4 covered with the light-shielding film 5 is embedded in the insulator layer 6.

[0029] On the insulator layer 6, facing each photoelectric

conversion unit 2 which is a light sensing unit, the pixel separation film 7 is formed for every pixel. The pixel separation film 7 has a square pyramid trapezoid shape, with an upper side getting to have a smaller area, a smooth top surface, and a bottom surface wider than a region (width) of the photoelectric conversion unit 2. Between adjacent two pixel separation films 7, the sectional V-shaped slot part 8 is formed by sloping sides facing each other of the pixel separation films 7. On each of the pixel separation films 7, the transparent film 9 having a refractive index lower than each pixel separation film 7 is laminated. On the surface of the transparent film 9 located on each slot part 8 formed between each adjoining pixel separation film 7, the concave lens 10 is formed having a dent, concave shape.

[0030] In the solid-state imaging device shown in FIG. 1, photosensitive transparent resin (for example, FUJIYAKUHIN Co., Ltd.: FVR) of refractive-index $n1 \fallingdotseq 1.6$ is used as the pixel separation film 7. This photosensitive transparent resin is applied with a thickness of 0.5 μm - 1.0 μm on the insulator layer 6, and the pattern of the square pyramid trapezoid shape of the pixel separation film 7 is formed by photo lithography. The pixel separation film 7 having the square pyramid trapezoid shape is formed as pattern for each predetermined unit cell which includes the photoelectric conversion unit 2 and a charge transfer unit (not shown). Here, the pattern formation of the pixel separation film 7 corresponding to one unit cell is divided for plural times, so that the pattern formation of the pixel separation films 7 corresponding to adjacent unit cells is not performed at the same time. Here, an inclination angle of the side surface of the pixel separation films 7 is changed in a range of 40 degrees to 80 degrees in a horizontal direction based on a light irradiation amount and a focal point of a light irradiation from a light source, and the sectional V-shaped slot part 8 is formed by sides facing each other of the adjoining two pixel

separation films 7. Thereby, the pixel separation films 7 having the square pyramid trapezoid shape are formed on positions facing all photoelectric conversion units 2, respectively.

[0031] Furthermore, fluorine system resin (for example, Asahi Glass Co., Ltd.: SAITOPPU) of a refractive-index $n2 \fallingdotseq 1.35$ that is lower than the pixel separation film 7 is used for the transparent film 9 laminated on every pixel separation film 7. This fluorine system resin is spin-spread with a thickness of 0.2 μm - 0.5 μm on the pixel separation film 7, and the transparent film 9 having the concave lens 10 of concave shape is formed in the upper part of the slot unit 8. The concave configuration of the concave lens 10 is adjusted with the viscosity of fluorine system resin, the number of rotations of spin spreading, etc.

[0032] With the above structure, the incident light which enters into the upper surface of the pixel separation film 7 from the surface of the concave lens 10 is irradiated on the light-receiving surface of the photoelectric conversion unit 2 through the pixel separation film 7, the insulator layer 6, and the interlayer film 3. The incident light which enters near the center part of the concave lens 10 formed on the transparent film 9 covering the slot unit 8 (shown by the arrow 11 of FIG. 1), and the incident light (shown by the arrows 12 and 13 of FIG. 1) which enters into the edge part side rather than the incident light (shown by the arrow 11 of FIG. 1) to the concave lens 10 is refracted on the surface of the concave lens 10, advances the inside of the transparent film 9, and is further refracted toward the photoelectric conversion unit 2 by the side of the pixel separation film 7. And it arrives at the light-receiving surface of the photoelectric conversion unit 2 through the inside of the pixel separation film 7, the insulator layer 6, and the interlayer film 3, and a signal charge is generated in the photoelectric conversion unit 2.

[0033] Therefore, in the solid-state imaging device shown in FIG. 1, most incident light which enters on the surface between concave

lenses 10 of the transparent film 9 and in the concave lens 10 is irradiated on the light-receiving surface of the photoelectric conversion unit 2, which can improve the photosensitivity of the photoelectric conversion unit 2.

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[0050] What is necessary is just to replace the pixel separation film 7 in each embodiment by a color filter, when applying the solid-state imaging device of the first, second, third, or fourth embodiment of the present invention to a color device etc. In this case, the refractive index n1 of the color filter is generally about $n1 \fallingdotseq 1.6$. The color filter having a square pyramid trapezoid shape is laminated with a constant interval on the insulator layer 6, facing the photoelectric conversion unit 2. For example, for the color filter, COLOR MOSAIC CM-8000 by Fujifilm Olin Co., Ltd., is used, and laminated with a thickness of 0.5 μm - 1.0 μm.

[0051] Although pattern formation of the color filter having a square pyramid trapezoid shape is carried out for every predetermined unit cell which includes the photoelectric conversion unit 2 and a charge transfer unit, the pattern formation of each color filter to one unit cell is divided into multiple times, so that the patterns of each color filter to the adjoining unit cells are not formed simultaneously. Thus, the color filters having a square pyramid trapezoid shape can be provided, facing the photoelectric conversion units 2, respectively.

[0052] Based on the light irradiation amount and the focus point of the light irradiation from the light source, an inclination angle of the side of the color filter having a square pyramid trapezoid shape is changed in a range from 40 degrees to 80 degrees in a horizontal direction.

[0053] When using the color filter having a square pyramid

trapezoid shape instead of the pixel separation film 7, since the center of the concave lens 10 formed on the surface of the transparent film 9 almost matches the boundary position (bottom of the slot unit 8) of adjacent color filters, it is possible to suppress that the incident light passing a predetermined color filter reaches the photoelectric conversion unit 2 facing an adjoining filter, and it is possible to prevent mixed colors by the variation etc. in a size in processing of the micro lens 15 formed on each color filter.

Fig. 1